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(54) **BATTERY PACK**

(75) Inventor: **Jungsoo Son**, Yongin-si (KR)

(73) Assignee: **Samsung Display Co., Ltd.**,
Gyeonggi-Do (KR)

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Primary Examiner — Thuan Do
(74) *Attorney, Agent, or Firm* — Knobbe, Martens, Olson &
Bear, LLP

(57)   **ABSTRACT**

A battery pack having a battery management system is dis-
closed. In some embodiments, the battery pack includes a
battery management system, which includes a detector
detecting a voltage and a current of each of the battery cells,
a current monitor receiving current information detected by
the detector, and a controller receiving voltage and current
information from the detector and current information from
the current monitor, and calculating capacities of the battery
cells based on the receive information.
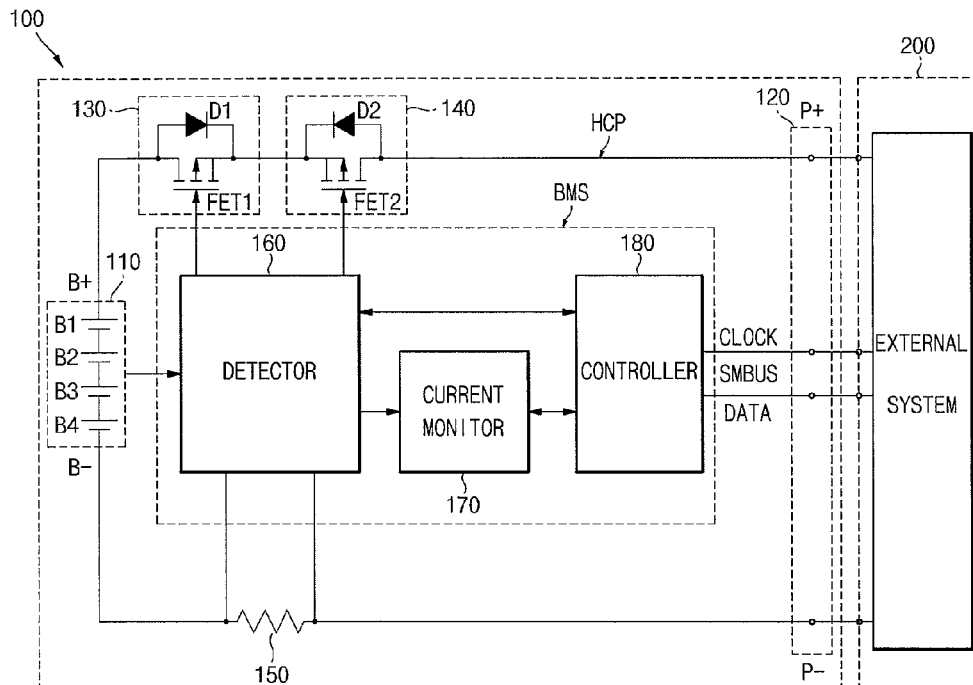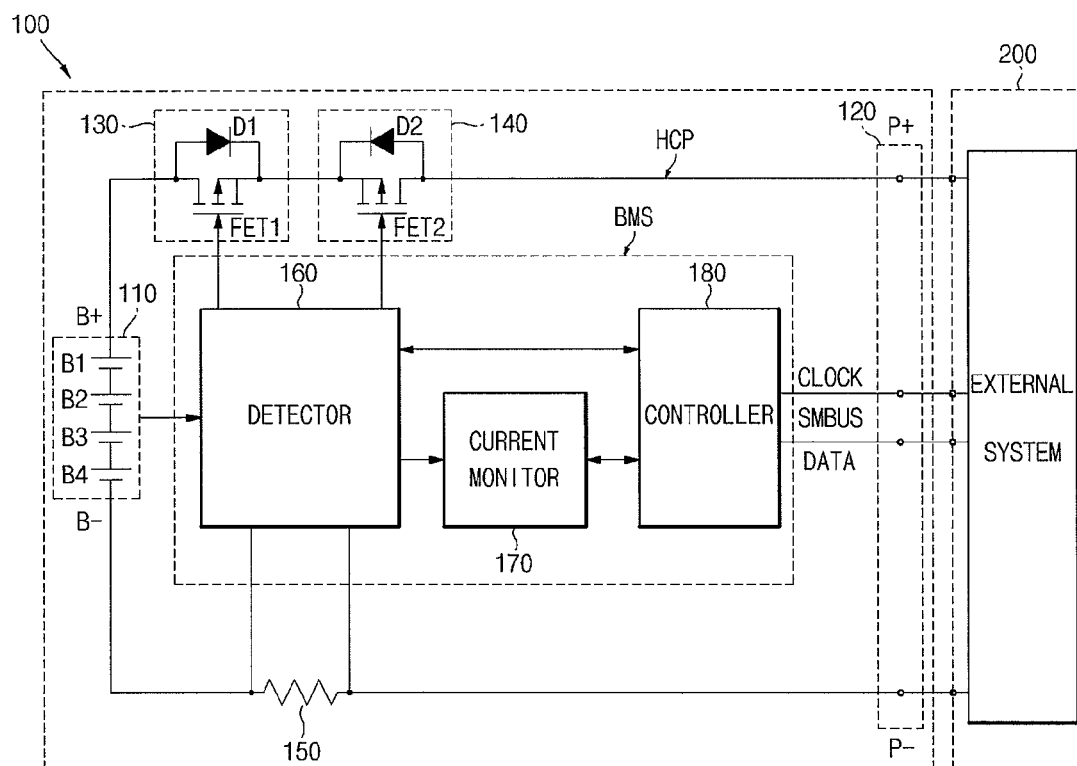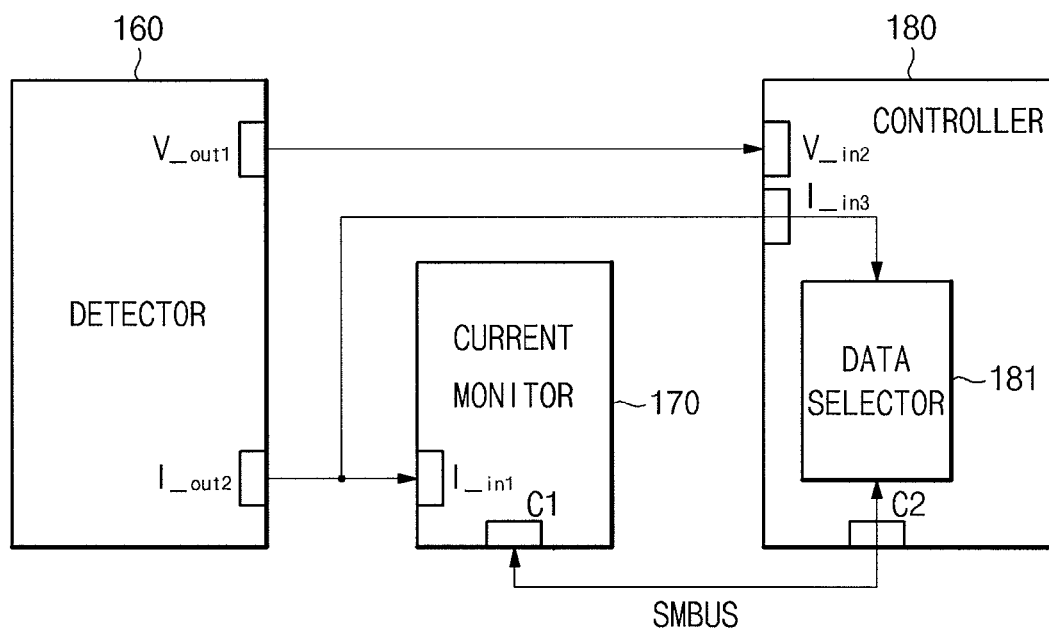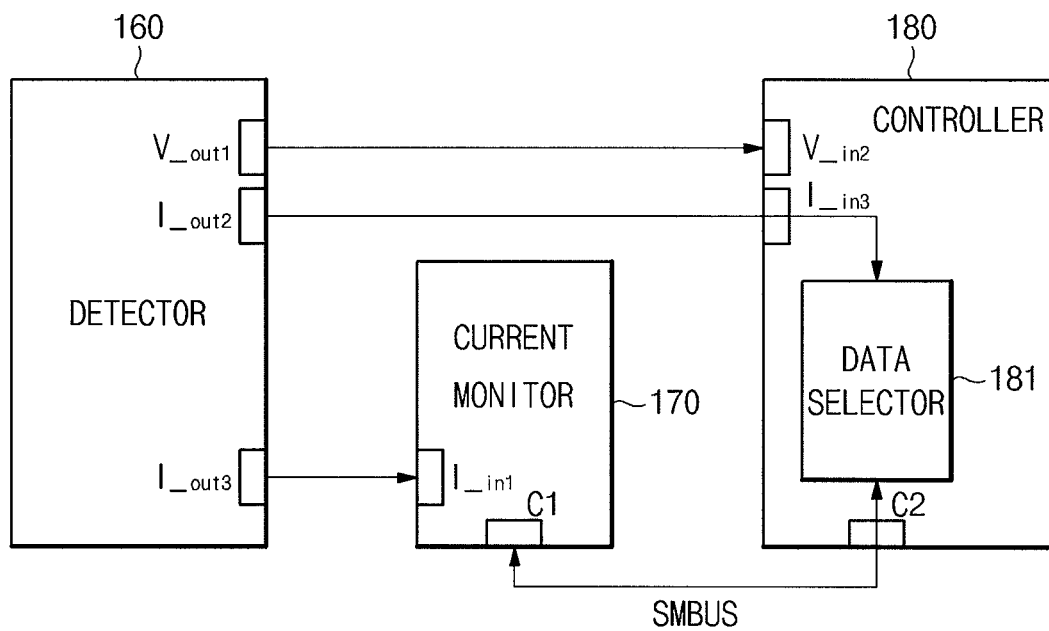
18 Claims, 2 Drawing Sheets

FIG. 1

160

DETECTOR

V$_{\_out1}$

I$_{\_out2}$

CURRENT MONITOR ～170

I$_{\_in1}$

C1

180

CONTROLLER

V$_{\_in2}$

I$_{\_in3}$

DATA SELECTOR ～181

C2

SMBUS

FIG. 3

160

DETECTOR

V$_{\_out1}$

I$_{\_out2}$

I$_{\_out3}$

CURRENT MONITOR ～170

I$_{\_in1}$

C1

180

CONTROLLER

V$_{\_in2}$

I$_{\_in3}$

DATA SELECTOR ～181

C2

SMBUS

BATTERY PACK

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Korean Patent Application No. 10-2011-0127380 filed on Nov. 30, 2011, the contents of which are incorporated herein by reference in their entirety.

BACKGROUND

1. Field

The disclosed technology relates to a battery pack, and more particularly to a battery pack having charging functions controlled according to status information.

2. Description of the Related Technology

In general, rechargeable secondary batteries are widely used for mobile electronic appliances such as cellular phones, notebook computers, camcorders, personal digital assistants (PDA) and the like. In addition, rechargeable secondary batteries are also used for electric vehicles such as e-bikes or e-scooters.

The secondary battery is fabricated in the form of a battery pack including battery cells and a battery management system, and charging or discharging of battery cells are performed by an external power supply or an external load through external terminals in the battery pack. In addition, the battery management system measures values of a voltage and a current, controls a protecting operation of battery cells based on the measured data, calculates a state of charge (SOC), and transmits processed information to the external system.

In a case of an e-bike or an e-scooter, current variations occur abruptly within a very short time. For example, city driving can entail frequent start-stops in traffic. Thus, in order for a battery management system to accurately calculate a battery capacity and to perform protecting operations at the right time, current monitoring should be performed at a high enough frequency to account for current variation in the e-bike or the e-scooter. However, a single chip formed in the battery management system generally implements control of the protection of battery cells and calculation of battery capacity. Thus, if the time for current monitoring is shortened, a current measurement load increases, so that other functions of the single chip cannot be performed. In addition, if the single chip is damaged due to a high current in a high-power system such as an e-bike or an e-scooter, functions of protecting operations and battery capacity calculation may not be possible.

SUMMARY OF CERTAIN INVENTIVE ASPECTS

Various aspects provide a battery pack which can operate stably in a high-power system.

One inventive aspect is a battery pack including one or more battery cells, a charging element and a discharging element configured to respectively control charging and discharging of the battery cells, and a detector configured to detect a voltage and a current of the battery cells. The battery pack also includes a current monitor configured to receive current information detected by the detector, and a controller configured to receive voltage and current information from the detector and current information from the current monitor, where the controller is configured to calculate capacities of the battery cells based on the received information and to control the charging and discharging elements.

Another inventive aspect is a battery management system, configured to control charging and discharging of one or more battery cells. The system includes a detector configured to detect a voltage and a current of the battery cells, a current monitor configured to receive current information detected by the detector, and a controller configured to receive voltage and current information from the detector and current information from the current monitor, where the controller is configured to calculate capacities of the battery cells based on the received information.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide further understanding of the present disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate certain embodiments and, together with the description, serve to explain principles of the present disclosure. In the drawings:

FIG. 1 is a circuit diagram schematically illustrating a configuration of a battery pack according to an embodiment;

FIG. 2 is a circuit diagram illustrating a connection between components of a battery management system shown in FIG. 1; and

FIG. 3 is a circuit diagram illustrating another connection between components of a battery management system shown in FIG. 1.

DETAILED DESCRIPTION OF CERTAIN INVENTIVE EMBODIMENTS

Example embodiments are described in more detail with reference to accompanying drawings.

FIG. 1 is a circuit diagram schematically illustrating a configuration of a battery pack according to an embodiment of the present invention. Referring to FIG. 1, the battery pack 100 includes a battery unit 110, an external terminal 120, a charging element 130, a discharging element 140, a sensor resistor 150 and a battery management system (BMS).

The battery pack 100 is connected to an external system 200 through the external terminal 120 and performs a charging or discharging operation. A high current path (HCP) established between the external terminal 120 and the battery unit 110 may be used as a charge/discharge path, and a relatively high current may flow through the HCP. The battery pack 100 may communicate with the external system 200 through a system management bus (SMBUS). For the purpose of communicating with SMBUS, the battery pack 100 may include a clock terminal (CLOCK) and a data terminal (DATA).

The external system 200 may include an external power supply or an external load. That is to say, the external system 200 may be a portable electronic device such as a portable notebook computer, and may include an external power supply such as an adapter (not shown) for supplying power. The battery unit 110 may be charged by the external power supply of the external system 200. If the external system 200 is disconnected from the external power supply and is connected to the external load, discharging from the battery unit 110 to the external load may be performed through the external terminal 120.

The battery unit 110 may include one or more battery cells B1, B2, B3 and B4 and may be charged or discharged to a constant voltage. Symbols B+ and B− shown in FIG. 1 denote high current terminals, which are a positive electrode power supply unit and a negative electrode power supply unit of battery cells B1, B2, B3 and B4 connected in series. While the

number of cells of the battery unit **110** is 4, that is, battery cells **B1**, **B2**, **B3** and **B4** are connected in series, the number of battery cells of the battery unit **110** may different, and may be determined, for example, based on power capacity required by the external load.

The external terminal **120** is connected to the battery unit **110** and is connected to the external system **200**, serving as a terminal during charging of the battery unit **110** or discharging of the battery unit **110**. In FIG. 1, P+ indicates a positive terminal connected to the positive electrode power supply unit (B+) of the battery unit **110**, and P− indicates a negative terminal connected to the negative electrode power supply unit (B−) of the battery unit **110**. The battery pack **100** is connected to the external power supply or the external load of the external system **200** through the external terminal **120**. That is to say, if the external system **200** connected to the external power supply is coupled to the external terminal **120**, charging from the external power supply to the battery unit **110** is performed. If the external load of the external system **200** is coupled to the external terminal **120**, discharging from the battery unit **110** to the external load is performed.

The charging element **130** and the discharging element **140** are connected in series on the HCP between the battery unit **110** and the external terminal **120**, and control charging and discharging of the battery pack **100**. Each of the charging element **130** and the discharging element **140** may include a field effect transistor (FET) and a parasitic diode (D). That is to say, the charging element **130** may include a field effect transistor (FET1) and a parasitic diode (D1). A source and a drain of the FET1 of the charging element **130** are connected in a direction opposite to a direction in which a source and a drain of the FET2 of the discharging element **130** are connected. With this configuration, the FET1 of the charging element **130** is connected to limit the flow of current from the external terminal **120** to the battery unit **110**, while the FET2 of the discharging element **140** is connected to limit the flow of current from the battery unit **110** to the external terminal **120**. Here, the FET1 and FET2 of the charging and discharging elements **130** and **140** may be, but not limited to, switching elements. In some embodiments, electric elements performing other types of switching operations are used instead of FET1 and FET2 of the charging and discharging elements **130** and **140**. In addition, the parasitic diodes D1 and D2 of the charging and discharging elements **130** and **140** are configured such that a current may flow in a direction opposite to a direction in which the flow of current is limited.

The sensor resistor **150** is connected in series on the HCP between the battery unit **110** and the external terminal **120**. Opposite ends of the sensor resistor **150** may be connected to the detector **160**. Accordingly, the sensor resistor **150** may sense charge and discharge currents of the battery unit **110** when the detector **160** detects voltage values of the opposite ends of or across the sensor resistor **150** and a resistance value of the sensor resistor **150**. Therefore, the sensor resistor **150** may function to transmit information concerning the charge current or the discharge current of the battery unit **110** to the detector **160**.

The BMS includes the detector **160**, a current monitor **170** and a controller **180**.

The detector **160** is connected to each of the battery cells **B1**, **B2**, **B3** and **B4** and detects voltages of the battery unit **110**. In addition, the detector **160** is connected to the sensor resistor **150** and detects charge and discharge currents of the battery unit **110**. In addition, the detector **160** may function to operate the charging element **130** and the discharging element **140** under the control of the controller **180**. The detector **160**

may be implemented, for example, by a protective circuit integrated circuit (IC) or an analog front end (AFE) integrated circuit (IC).

For example, if the external system **200** is an external power supply, the detector **160** sets the FET1 of the charging element **130** to an 'ON' state and the FET2 of the discharging element **140** to an 'ON' state to charge the battery unit **110**. Likewise, if the external load of the external system **200** is coupled to the battery unit **110**, the detector **160** sets the FET1 of the charging element **130** to an 'ON' state and the FET2 of the discharging element **140** to an 'ON' state to discharge the battery unit **110**. Meanwhile, although not shown, the detector **160** may detect voltages of the respective battery cells **B1**, **B2**, **B3** and **B4**.

A signal indicative of the voltage or current detected from the detector **160** may be transmitted to the current monitor **170** and the controller **180** as analog signals, and information concerning the transmitted analog signals may be converted into digital information by the current monitor **170** and the controller **180**.

The current monitor **170** may receive and store the current information detected from the detector **160** at a predetermined frequency (to be referred to as a first frequency). The first frequency is described below. The current monitor **170** may include a memory (not shown) for storing information. The memory may serve as a buffer. In addition, if the current information received from the detector **160** is an analog signal, the current monitor **170** may include an analog-to-digital (A/D) converter (not shown) for storing digital information. The A/D converter converts the analog current signal received from the detector **160** into a digital signal and stores the digitally converted current signal in the memory.

The controller **180** may receive voltage information and current information from the detector **160** and current information from the current monitor **170**, respectively, and may calculate a status or a capacity of the battery unit **110**, e.g., a state of charge (SOC), based on the received information. Here, the controller **180** may include a memory (not shown) for storing the information received from the detector **160** or the current monitor **170**.

The controller **180** may receive current information from the detector **160** at a predetermined frequency (to be referred to as a second frequency). The second frequency is described below. In addition, the controller **180** may read the current information stored in the memory of the current monitor **170** through SMBUS communication at a predetermined frequency. The frequency of the controller **180** reading the current information from the current monitor **170** may or may not be substantially equal to the frequency of receiving the current information from the detector **160**.

The controller **180** may further include a data selector **181** that selects the current information received from the detector **160** or the current information received from the current monitor **170**, for example, according to whether the current monitor **170** operates or not.

In some embodiments, the controller **180** reads the current information stored in the memory of the current monitor **170** through SMBUS communication at a predetermined frequency and calculates the capacity of the battery unit **110** based at least in part on the current information. However, when the battery pack **100** is used in a high-power system such as an e-bike or an e-scooter, a high current may flow in the system, so that the current monitor **170** may be damaged, resulting in malfunctioning. In this case, in order to allow the controller **180** to normally operate for calculation of battery capacity, for example, the current information for the battery unit **110**, may be received directly from the detector **160**. As

described above, the data selector **181** determines whether the current information received from the current monitor **170** or the current information received from the detector **160** is to be used according to whether the current monitor **170** operates or not, and selects the current information.

The operation of the data selector **181** is described in more detail. The data selector **181** determines whether the current monitor **170** operates or not, and selectively uses the current information received from the detector **160** or the current monitor **170** based on the determination result.

For example, in a case where the current information is read from the memory (not shown) of the current monitor **170**, the data selector **181** determines that the current monitor **170** normally operates, selects the current information read from the current monitor **170** and stores the same in the memory to be used in the controller **180** for calculating the capacity of the battery unit **110**.

Conversely, if the current information is not received from the memory (not shown) of the current monitor **170**, the data selector **181** determines that the current monitor **170** does not normally operate and selects and stores the current information received from the detector **160**. Thus, even in a case where the current monitor **170** does not operate, the charge/discharge current information of the battery unit **110** can be continuously monitored, thereby allowing the controller **180** to perform normal operations.

If the current information received from the detector **160** is an analog signal, the controller **180** may include an A/D converter (not shown) for storing digital information. The A/D converter may convert the analog current signal received from the detector **160** into a digital signal and then store the same in the memory (not shown).

The controller **180** may additionally or alternatively receive voltage information from the detector **160** and may control a protecting operation of the battery unit **110**.

For example, if the voltage received from the detector **160** is greater than a preset over-charge level voltage value in the controller **180**, the controller **180** may determine an over-charge state, and output an over-charge control signal corresponding to the over-charge state to the detector **160**. The detector **160** receives the over-charge control signal from the controller **180** and turns off the FET**1** of the charging element **130**. Accordingly, charging from the external power supply of the external system **200** to the battery unit **110** is interrupted. Here, even if the FET**1** of the charging element **130** is turned off, the parasitic diode D**1** of the charging element **130** allows the battery pack **100** to perform discharging.

Conversely, if the voltage received from the controller **180** is not greater than a preset over-charge level voltage value in the controller **180**, the controller **180** may determine an over-discharge state, and output an over-discharge control signal corresponding to the over-discharge state to the detector **160**. The detector **160** receives the over-discharge control signal from the controller **180** and turns off the FET**2** of the discharging element **140**. Accordingly, discharging from the battery unit **110** to the external load of the external system **200** may be interrupted. Here, even if the FET**2** of the discharging element **140** is turned off, the parasitic diode D**2** of the discharging element **140** allows the battery pack **100** to perform charging.

The first frequency and the second frequency are described in more detail.

At the first frequency, the current monitor **160** receives the current signal detected by the detector **160**. At the second frequency, the controller **180** receives the current information detected by the detector **160**.

The first and second frequencies may or may not be different from each other. In some embodiments, the first frequency is less than the second frequency. In addition, the first frequency may be higher than a current variation frequency of the battery unit **110**.

If an e-bike or an e-scooter, for example, is driven, current variation occurs abruptly. For example, if an e-bike is driven, there may be traveling waves and regenerative current waves. A current peak cycle, that is, a current variation cycle, in the traveling waves may be less than, for example, approximately 500 ms, and a current peak cycle in the regenerative current waves may be less than, for example, approximately 20 ms. However, since a current variation cycle of a general controller is longer than that of an e-bike or an e-scooter, it is not possible to detect the current variations. In addition, if a short current measurement time is set in the general controller, a measurement load is increased, thereby preventing the controller **180** from performing basic operations, including battery protection or communication.

The current monitor **170** according to one embodiment of the may repeatedly measure and store the current detected by the detector **160** on a first cycle shorter than a second cycle of the controller **180** and shorter than a current variation cycle in an e-bike or an e-scooter. For example, the first cycle may be set to be in a range of about 5 ms to about 10 ms. In addition, the controller **180** may read the current information stored in the current monitor **170** on a predetermined cycle, perform protection and capacity calculation of the battery unit **110** and transmit the processed information to the external system **200**.

FIG. **2** is a circuit diagram illustrating connection relationships between components of a battery management system shown in FIG. **1**. Referring to FIG. **2**, the detector **160** may include a first output port V_{out1} and a second output port I_{out2}. The first output port V_{out1} may be a port for outputting the voltage information detected from the battery unit **110**, and the second output port I_{out2} may be a port for outputting the current information detected from the battery unit **110**.

The current monitor **170** may include a first input port and a first communication port C**1**. Here, the first input port I_{in1} may be electrically connected to the second output port I_{out2} and may receive a current signal from the detector **160**. The first communication port C**1** is a port for outputting the current information stored in the current monitor **170** to the controller **180** and communicating with the controller **180**. Here, the first communication port C**1** may be connected to a second communication port C**2** of the controller **180**, which is described below, and may perform system management bus (SMBUS) communication.

The controller **180** may include a second input port V_{in2}, a third input port I_{in3} and the second communication port C**2**. The second input port V_{in2} may be electrically connected to the first output port V_{out1} of the detector **160** and may receive voltage information from the detector **160**. The third input port I_{in3} may be electrically connected to the second output port I_{out2} of the detector **160** and a connection node of the first input port I_{in1} of the current monitor **170** and may directly receive the current information detected from the detector **160**. In addition, the third input port I_{in3} may also be connected to the data selector **181** to allow the current information received from the detector **160** to be transmitted to the data selector **181**. The second communication port C**2** may be electrically connected to the first communication port C**1** of the current monitor **170** to allow, for example, an information request signal of the controller **180** to be transmitted to the current monitor **170**, and may receive

the current information stored in the current monitor **170** in response to the information request signal.

FIG. **3** is a circuit diagram illustrating another connection relationship between components of a battery management system shown in FIG. **1**. Referring to FIG. **3**, the detector **160** may include a first output port $V_{\_out1}$, a second output port $I_{\_out2}$ and a third output port $I_{\_out3}$. Here, the first output port $V_{\_out1}$ may be a port for outputting the voltage information detected from the battery unit **110** and the second output port $I_{\_out2}$ and the third output port $I_{\_out3}$ may be ports for outputting the current information detected from the battery unit **110**.

The current monitor **170** may include a first input port $I_{\_in1}$ and a first communication port C**1**. Here, the first input port $I_{\_in1}$ may be electrically connected to the third output port $I_{\_out3}$ and may receive a current signal from the detector **160**. The first communication port C**1** may be a port for outputting the current information stored in the current monitor **170** to the controller **180** and communicating with the controller **180**. Here, the first communication port C**1** may be connected to a second communication port C**2** of the controller **180**, which is described below, and may perform system management bus (SMBUS) communication.

The controller **180** may include a second input port $V_{\_in2}$, a third input port $I_{\_in3}$ and a second communication port C**2**. The second input port $V_{\_in2}$ may be electrically connected to the first output port $V_{\_out1}$ of the detector **160** and may receive voltage information from the detector **160**. The third input port $I_{\_in3}$ may be electrically connected to the second output port $I_{\_out2}$ of the detector **160** and may directly receive the current information detected from the detector **160**. In addition, the third input port $I_{\_in3}$ may also be connected to the data selector **181** to allow the current information received from the detector **160** to be transmitted to the data selector **181**. The second communication port C**2** may be electrically connected to the first communication port C**1** of the current monitor **170** to allow an information request signal of the controller **180** to be transmitted to the current monitor **170**, and may receive the current information stored in the current monitor **170** in response to the information request signal.

According to some embodiments, in a high-power system such as an e-bike or an e-scooter, the current monitor may protect the controller from a high current that flows in the system, thereby allowing the controller to perform normal operations.

In addition, the current monitor can disperse a current measurement load and can monitor a current within a shorter time than a current variation cycle of the high-power system, thereby measuring an instantaneous maximum current value. Accordingly, current measurement errors can be reduced, and more accurate current monitoring is enabled.

Certain embodiments have been disclosed herein, and although specific terms are employed, they are used and are to be interpreted in a generic and descriptive sense only and not for purpose of limitation. Accordingly, it will be understood by those of ordinary skill in the art that various changes in form and details may be made without departing from the spirit and scope of the present disclosure as set forth in the following claims.

What is claimed is:

1. A battery pack comprising:

one or more battery cells;

a charging circuit and a discharging circuit configured to respectively control charging and discharging of the battery cells;

a detector configured to detect a voltage and a current of the battery cells;

a current monitor configured to receive current information detected by the detector; and

a controller configured to receive voltage and current information from the detector and current information from the current monitor, wherein the controller is configured to calculate capacities of the battery cells based on the received information and to control the charging and discharging circuits,

wherein the detector includes a first output port for outputting the voltage information detected from the battery cells, and a second output port for outputting the current information detected from the battery cells, wherein the current monitor includes a first input port connected to the second output port and a first communication port for outputting the current information received from the detector and communicating with the controller, and wherein the controller includes a second input port connected to the first output port, a third input port connected to the second output port, and a second communication port connected to the first communication port.

2. The battery pack of claim **1**, wherein the current monitor further comprises a memory to store the current information received from the detector.

3. The battery pack of claim **1**, wherein the current monitor receives the current information from the detector at a first frequency, the controller receives the current information from the detector at a second frequency, and the first and second frequencies are different from each other.

4. The battery pack of claim **3**, wherein the period associated with the first frequency is shorter than a current variation cycle of each of the battery cells.

5. The battery pack of claim **1**, wherein the current monitor receives the current information from the detector at a first frequency, the controller receives the current information from the detector at a second frequency, and the first frequency is greater than the second frequency.

6. The battery pack of claim **5**, wherein the period associated with the first frequency is shorter than the current variation cycle of each of the battery cells.

7. The battery pack of claim **1**, wherein the controller further comprises a data selector configured to select the current information received from the current monitor or the current information received from the detector according to whether the current monitor operates or not.

8. The battery pack of claim **7**, wherein the data selector selects the current information received from the current monitor if the current monitor operates, and selects the current information received from the detector if the current monitor does not operate.

9. A battery pack comprising:

one or more battery cells;

a charging circuit and a discharging circuit configured to respectively control charging and discharging of the battery cells;

a detector configured to detect a voltage and a current of the battery cells;

a current monitor configured to receive current information detected by the detector; and

a controller configured to receive voltage and current information from the detector and current information from the current monitor, wherein the controller is configured to calculate capacities of the battery cells based on the received information and to control the charging and discharging circuits,

wherein the detector includes a first output port for outputting the voltage information detected from the battery cells and second and third output ports for out-

putting the current information detected from the battery cells, wherein the current monitor includes a first input port connected to the third output port, and a first communication port for outputting the current information received from the detector and communicating with the controller, and wherein the controller includes a second input port connected to the first output port, a third input port connected to the second output port and a second communication port connected to the first communication port.

10. A battery management system, configured to control charging and discharging of one or more battery cells, the system comprising:

a detector configured to detect a voltage and a current of the battery cells;

a current monitor configured to receive current information detected by the detector; and

a controller configured to receive voltage and current information from the detector and current information from the current monitor, wherein the controller is configured to calculate capacities of the battery cells based on the received information,

wherein the detector includes a first output port for outputting the voltage information detected from the battery cells, and a second output port for outputting the current information detected from the battery cells, wherein the current monitor includes a first input port connected to the second output port and a first communication port for outputting the current information received from the detector and communicating with the controller, and wherein the controller includes a second input port connected to the first output port, a third input port connected to the second output port, and a second communication port connected to the first communication port.

11. The system of claim **10**, wherein the current monitor further comprises a memory to store the current information received from the detector.

12. The system of claim **10**, wherein the current monitor receives the current information from the detector at a first frequency, the controller receives the current information from the detector at a second frequency, and the first and second frequencies are different from each other.

13. The system of claim **12**, wherein the period associated with the first frequency is shorter than a current variation cycle of each of the battery cells.

14. The system of claim **10**, wherein the current monitor receives the current information from the detector at a first frequency, the controller receives the current information from the detector at a second frequency, and the first frequency is greater than the second frequency.

15. The system of claim **14**, wherein the period associated with the first frequency is shorter than the current variation cycle of each of the battery cells.

16. The system of claim **10**, wherein the controller further comprises a data selector configured to select the current information received from the current monitor or the current information received from the detector according to whether the current monitor operates or not.

17. The system of claim **16**, wherein the data selector selects the current information received from the current monitor if the current monitor operates, and selects the current information received from the detector if the current monitor does not operate.

18. A battery management system, configured to control charging and discharging of one or more battery cells, the system comprising:

a detector configured to detect a voltage and a current of the battery cells;

a current monitor configured to receive current information detected by the detector; and

a controller configured to receive voltage and current information from the detector and current information from the current monitor, wherein the controller is configured to calculate capacities of the battery cells based on the received information, wherein the detector includes a first output port for outputting the voltage information detected from the battery cells and second and third output ports for outputting the current information detected from the battery cells, wherein the current monitor includes a first input port connected to the third output port, and a first communication port for outputting the current information received from the detector and communicating with the controller, and wherein the controller includes a second input port connected to the first output port, a third input port connected to the second output port and a second communication port connected to the first communication port.

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